BOOTH, FRERET & IMLAY, LLC

ATTORNEYS AT LAW

ROBERT M. BOOTH, JR. (1911-1981)
JULIAN P. FRERET (1918-1999)
CHRISTOPHER D. IMLAY

14356 CAPE MAY ROAD
SILVER SPRING, MD 20904-6011
WWW.IMLAYLAW.COM

TELEPHONE: (301) 384-5525
FACSIMILE: (301) 384-6384
CHRIS@IMLAYLAW.COM

January 2, 2019

Ex Parte

Marlene H. Dortch, Secretary
Federal Communications Commission
445-12th Street, S.W.
Washington, DC 20554

Re: Mobile Device Indoor Z-Axis Location Determination;
PS Docket No. 07-114; **Written Ex Parte Presentation**;
Robert Bosch LLC

Dear Ms. Dortch:

In mid-December of 2018, the undersigned, communications counsel for Robert Bosch LLC (Bosch) was contacted by a member of the Commission's staff in the Public Safety and Homeland Security Bureau. The staff member noted that the Commission currently has an open proceeding concerning mobile device indoor Z-Axis location determination. One of the methods of determining the Z-Axis information is through the use of Barometric Pressure Sensors (BPS). A division of Bosch, Bosch Sensortec, is a major BPS manufacturer for various types of mobile devices. The Bureau staff posed a series of questions intended to inform the staff relative to the above-referenced docket proceeding, which it asked Bosch staff to address.

The questions, and Bosch's responses to them, are set forth in the attachment. While Bosch has not participated in any way heretofore in this docket proceeding, and while the attached document is in response to a Commission staff enquiry and Bosch takes no position with respect to the issues in the docket proceeding, it nonetheless appears necessary to submit the attached questions and answers as a written ex parte presentation.

Should any question arise concerning the attachment to this letter, kindly notify the undersigned, communications counsel for Robert Bosch LLC.

Respectfully submitted,

Christopher D. Imlay

Attachment

Questions for Barometric Pressure Sensor Manufacturers
Bosch - Z Axis meeting

(December 6, 2018)

Our focus is on Barometric Pressure (BP) sensors that go into mobile devices!

- Bosch has been making BP sensors for several years. Have you observed the Moore's Law for BP sensors?
    - No, BPs don't scale with Moore's law. They are made up by two elements 1) the ASIC and 2) the MEMS (Micro Electrical Mechanical System) membrane
        - 1) Scale with Moore's law but more features are added at every generation, therefore the die size is roughly constant
        - 2) Doesn't scale because the membrane needs to have a minimum physical size to achieve the target performance.

- How many generations of Bosch cell phone BP sensors has there been? How many years between each generation?
    - Speaking for Bosch BP for consumer electronics we can summarize as
        - BMP085 = from 2008 to 2011
        - BMP180 = from 2011 to 2016
        - BMP280 = from 2013 and currently in mass production
        - BMP380 = from 2017 and currently in mass production
    - Datasheets of these components are publicly available on the internet for example here https://www.bosch-sensortec.com/bst/products/environmental/barometric_pressure_sensors/overview_barometricpressuresensors

- How has Bosch BP sensors performance have improved over years and over generations (aging and model issue)?
    - Each generation brought about improvements in
        - Package size (smaller)
        - Relative accuracy (improved)
        - Absolute accuracy (improved)
        - Manufacturing cost (decreased)
        - TCO (temperature dependency of the offset)
        - Power consumption (decreased)

- Do you have historical lab and field performance data that you can share with the FCC, or at least describe to us?

- Bosch collects component-level lab and field performance data but it are only released under NDA, typically to smartphone manufacturers. However, we do stand behind our datasheet minimum/typical/maximum values resulting from our lifetime and after-soldering characterizations. The end customer will expect the lifetime performances to fall within these datasheet values.

- Supposedly, your lab test data is also collected inside buildings with central air. How do you address building-effect calibration issues?
  - Given the pressure resolution, all consumer BP components (not just Bosch's) are sensitive to weather- and building-effects. During our lab testing, calibration and characterization, we work in pressure and temperature controlled environments.

- Do you know how closely your data correlates with cell phone data (or data wireless carriers collect during their testing using your chips in their cell phones)?
  - Bosch is a component manufacturer and, as such, we provide the drivers and temperature compensation open source algorithms to run on the host processor(s). Sensor data are used and compensated (e.g. sea level compensation) by the smartphone manufacturer and the app developers.

- Do you know, or have you seen any performance difference between Android and iOS phones (OS issue)?
  - In principle, the data and performance of the individual components do not depend on the operating systems. Data compensation (e.g. sea level compensation) is up to the smartphone manufacturer and app developers.

- Have you seen CTIA Test Bed Z Axis data? How does it compare with your own lab/field test data?
  - We have seen some portions of the CTIA test bed Z axis data. It shows the result of different systems (e.g. NextNav and Polaris Wireless) that use BP data from MEMS sensors and other compensation algorithms to derive absolute altitude. Without external systems of these kinds, BP alone cannot provide absolute altitude. In our view, they do show that a consumer-grade BP sensor is the necessary starting point of an operator-assisted compensation system to derive the useful absolute altitude readings. Such altitude will have beneficial uses also beyond the e-911 use cases.

- How would severe weather (temperature and wind chill) impact BP sensor reading and calibration?
  - A key performance indicator of a pressure sensor is its TCO (see previous question above). A low temperature offset dependency, together with an efficient algorithm, is able to bring the temperature-related fluctuations to a level that is compatible to a

useable altitude estimation. For example, Bosch's BMP380 TCO is ±0.75 Pa/K (25°...40°C @ 900 hPa). Competitor parts are expected to reach these levels too.
    - Source: https://www.bosch-sensortec.com/bst/products/all_products/bmp380

- Some general Cost/Performance discussion
    - As with all components, increased BP adoption is resulting in price erosion and these sensors are becoming commodities in the BOM (bill of materials) of smartphones. Some smartphone customers are paying premiums in exchange of water-resistant and waterproof versions of BPs.

CALIBRATION:

- Could you please describe various types of calibrations and frequency of calibration needed to get the most accurate reading with your cell phone BP sensors.
    - Each BP is calibrated individually during manufacturing in order to achieve the committed datasheet specifications.
    - Bosch recommends in-line calibration of pressure sensors after they are soldered. An NDA-covered application note is provided to the OEM's manufacturing line to document this calibration.

- Given that our focus is on cell phones used inside building (mostly) with central air system, what are your recommendations for cell phone BP sensor calibration to get the most accurate reading?
    - The determination of absolute altitude is possible through a compensation at system level (e.g. Nextnav's system).
    - Uncompensated barometric data on its own may not be enough to identify the altitude of a caller inside a building unless a similar device (e.g. a "homing" system carried by a first responder) can correlate to the e-911 caller in real time.

- Any other recommendations or information you like to share with the FCC?
    - A higher availability of local absolute pressure sensor readings (e.g. each wireless hotspot, 5G cell, etc.) will allow mobile-based devices to more efficiently compensate to an absolute altitude reading – see for example US patent https://patents.google.com/patent/US20160033286